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URANIUM CONTENT OF SEWAGE SLUDGE
OAK RIDGE DISPOSAL PLANTS

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Abstract

Results of tests are given on the uranium content of sludge which is produced at the Oak Ridge sewage disposal plants. The sludge produced at the West Plant is reported to contain 25 to 50 p.p.m. of uranium, and that produced at the East Plant is reported to be of the order of 5 to 10 p.p.m.

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Oak Ridge, Tennessee
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URANIUM CONTENT OF SEWAGE SLUDGE
OAK RIDGE DISPOSAL PLANTS

INTRODUCTION

The work, reported herein, was undertaken for the purpose of determining the concentration of uranium in the sewage sludges which are produced at the Oak Ridge disposal plants. It had appeared, on the basis of reports received by us, that the uranium concentration was of such magnitude as to be of some concern to the staff at Y-12, particularly because the sanitary sewage from the Y-12 plant is the only plant sewage which has at one time or another been a part of the influent to these disposal plants. The sewage from K-25 and X-10 are processed at some other location and, consequently, do not contribute to the influent at either the East or West Plant.

It was believed that an unusually high uranium content in the sewage sludge could be interpreted as being indicative of accidental or intentional disposal of SF materials into the sanitary-sewer system. Although SF materials are not knowingly or intentionally disposed of in this manner, it would be of considerable interest to determine if the presence of uranium in the sewage sludge could be used as a criterion of actual losses of uranium-bearing materials. Furthermore, a high uranium content might conceivably indicate the necessity for reviewing process methods to determine the source of these losses.

In addition to the more obvious sources of loss (mentioned above), it is probably of greater significance from a health standpoint to determine to what extent uranium is introduced into the sewage by other means, such as:

Body excreta--feces, urine, etc.
Personal hygiene--bathing
Clothing--laundering
Dust and dirt--carried on shoes and by the atmosphere into residences

Since the sewage from the town of Oak Ridge is also directed to these disposal plants, any considerations as to the causes for the uranium pick-up in the sludge should include the possibility that the contamination is due to those causes mentioned in the preceding sentences.

Originally, both the Y-12 and city sewage were treated at the East Plant. The West Plant started operations in May, 1944, and at that time all the Y-12 sewage and part of the city sewage were diverted to the West Plant. Since May, 1944, the East Plant has been used exclusively for processing a portion of the city sewage and any uranium build-up in the sludge at this disposal plant after that date is probably due to body excreta, laundering of clothing, dirt, dust, etc., from the residential area rather than to spillage or losses occurring at Y-12.

A discussion of the test results and of the methods of sampling, sample preparation and analysis is presented herewith.

METHODS

Description of Samples

Two series of samples were analyzed. The first series of four samples was secured on August 2, 1948, from each of the two disposal plants. The samples were taken from material lying on the sand filters (in the process of filtration) or, in the case of the older material, on the sludge dumps.

The samples were identified as to the relative dates on which they were dumped, and are as follows:

<u>Lab. No.</u>	<u>Disposal Plant</u>	<u>Date Dumped</u>	<u>Comments</u>
33245	East Oak Ridge	March, 1944	Weathered four years
33244	East Oak Ridge	July, 1948	Processed August 2, 1948
33247	West Oak Ridge	May, 1944	Weathered four years
33246	West Oak Ridge	August, 1948	Processed August 2, 1948

Since greater precision than that obtained with the first series of samples was desired, a second series of sludge samples was taken on September 8 and 9, 1948. For the purpose of providing information as to relative background (control), one sample of sludge was secured from the disposal plant at Norris, Tennessee, and subjected to the same analyses as the Oak Ridge samples. Six samples were taken from the disposal plant in West Oak Ridge. One of these samples (Lab. No. 34206) was representative of the influent to the digester (predigested sludge). The other five samples were taken from solids lying on the sand filters or from material on the sludge dumps (which had been exposed to different degrees of weathering). These samples are identified according to the location from which they were taken, and are as follows:

<u>Lab. No.</u>	<u>Type of Sample</u>	<u>Source</u>
34205	Filtered solids	North filter beds at Norris, Tenn.
34206	Predigested sludge	West Oak Ridge Disposal Plant
34207	Solids (New deposits)	Filter beds West Oak Ridge
34208	Solids (New deposits)	West Oak Ridge sludge dump 335 ft. west and 4 ft. north of tower number 1431 on the TVA power line to the K-25 plant
34209	Solids (New deposits)	West Oak Ridge sludge dump 247 ft. west and 34 ft. north of tower 1431
34210	Solids (New deposits)	West Oak Ridge sludge dump 300 ft. west and 144 ft. south of tower 1431
34211	Solids (Aged, weathered deposit)	West Oak Ridge sludge dump about 375 ft. west and 150 ft. south of tower 1431

The solids were sampled at a number of points in the general vicinity already described. In each case, an attempt was made to avoid collecting the dried crust of the material on the outer portion of the deposit in order to diminish the effects of leaching and weathering as much as possible.

Dissolution of Samples

The method of preparing the samples for analysis differed somewhat between the two series of tests. In the second series, a greater effort was made to obtain homogeneous samples, and the size of the samples analyzed was increased from 10 to 25 grams. A detailed outline of the methods of preparing and dissolving the samples is given in Appendix A.

Method of Determining Uranium

The uranium content of the solutions was determined fluorimetrically after extraction of the aqueous phase with penta-ether. The uranium concentrations of the samples as reported herein are calculated on dry bases. The percent loss on drying was determined for each sample to permit calculating the concentration of uranium in the samples on a wet basis if it is so desired.

TEST RESULTS

The test results are reported in the following tables:

Series IUranium and Moisture Content of Sewage Sludge

Lab. No.	Disposal Plant	Moisture Percent	Uranium in Parts Per Million (Dry Basis)					Ave.	
			Test 1	Test 2	Test 3	Test 4			
33245	East	11.7	1.0	17	13	7.4	9.6	Weathered 4 yr.	
33244	East	74	3.4	4.6	1.7	2.9	3.2	New	
33247	West	14.2	56	59	*22	49	47	Weathered 4 yr.	
33246	West	79	41	95	20	49	51	New	

*Determined colorimetrically with l-ascorbic acid

Series IIUranium and Moisture Content of Sewage Sludge

<u>Lab. No.</u>	<u>Source</u>	<u>Moisture Percent</u>	<u>Uranium in Parts Per Million (Dry Basis)</u>				<u>Ave.</u>
			<u>Test 1</u>	<u>Test 2</u>	<u>Test 3</u>		
34205	Filter beds, Norris Plant	31	0.8	0.8			0.8
34206	Predigester, West Plant	97.9	9.8	2.9	3.6		5.4
34207	Filter beds, West Plant	79.5	33	26			30
34208	Dump, West Plant (New)	60.0	32	30			31
34209	Dump, West Plant (New)	62.4	27	23			25
34210	Dump, West Plant (New)	53.6	28	25			27
34211	Dump, West Plant (Old)	48.5	63	72			68

DISCUSSION OF TEST RESULTS

Series I

Even though the test results of the first series vary over a wide range, there are indications of definite observable trends. It would appear on the basis of analyses of both old and new sludge deposits, that the material produced at the East Plant contained appreciably less uranium than was

found in the sludge produced at the West Plant. It will be recalled that operations at Y-12 prior to May, 1944, involved considerably less uranium than at any subsequent date and, such being the case, there would be a lesser expectancy of finding increased amounts of uranium in sludge processed in advance of that date. Furthermore, the concentration of uranium in the sludge produced in 1948 at the East Plant is considerably less (about one-third) than that of the sludge produced in 1944. It could be said that the lesser uranium concentration of 2.4 p.p.m. (corrected from 3.2 p.p.m. on the basis of 0.8 p.p.m. found in the Norris deposit) is derived exclusively from the city sewage and gives some indications of the minimal quantities of uranium which are being carried out of all operational areas on clothing and in the bodies of working personnel.

Series II

An examination of the test results of the second series reveals that the precautions which were taken to increase the precision and reliability of the data were effective, but, even so, it is also clearly indicated from either series of tests that the uranium content of the sludge from the West Plant is greater by a factor of ten than that of the sludges produced at the East Plant. The uranium content of the sludge produced at the West Plant is of the order of 30 parts per million.

Since the uranium content of the sewage as it leaves Y-12 is of the order of 10 parts per billion, based on the analyses of some 120 samples of Y-12 sewage, it would appear that concentration of the uranium into the sludge occurs during the processing of the sewage. If such a phenomenon is actually taking place, it would appear that sewage disposal techniques might be used profitably for other purposes.

An attempt was made to correlate the uranium content of the product

sludge with that of the influent, but such proved futile. It was postulated that such correlation was not possible since the effects of other factors such as the uranium content of the effluent, rate of sludge decomposition, weathering and leaching effects, and degree of contamination with sand and earth were not known or could not be approximated.

Even though the uranium content of the sludge produced at the West Plant appears to be excessive (25 to 50 p.p.m.), it is significant to note that the concentration is much less than that of any material which is currently being used or considered as a source of uranium.

SUMMARY

Analyses of the sludge produced at the West Oak Ridge Disposal Plant indicate that the sludge contains 25 to 50 parts per million of uranium (on a dry basis).

On this same basis, it appears that the uranium content of the sludge from the East Plant is of the order of 5 to 10 parts per million.

In either case, the uranium content is much lower than that of the least practicable workable source of uranium (oil shale--100 to 200 p.p.m.).

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APPENDIX A

Procedure for the Preparation and Dissolution of Samples

Series I

1. Weigh a 10-gram sample of the sludge as received.
2. Leach the sludge twice with 1:3 nitric acid solution.
3. Filter the solutions and discard the solids remaining after the second leach.
4. Combine the filtrates from step 2, add perchloric acid and evaporate to fumes to destroy organic matter.
5. Cool and dilute with water and nitric acid.
6. Boil the solution and precipitate the elements of the R_2O_3 group with ammonium hydroxide.
7. Filter and dissolve the precipitate with dilute nitric acid and dilute to volume.
8. Weigh a second portion of original sample and dry at $110^\circ C$. for 12 hours. Reweigh and calculate the percent loss on drying.

Series II

1. Weigh the entire sample and dry for approximately 12 hours.
2. Cool, reweigh, and calculate the percent loss on drying.
3. Grind the sample to about 60 mesh and mix thoroughly.
4. Weigh 25 grams (10 grams from sample 34206) of the dried sludge and ignite at $600^\circ C$.
5. Treat the ignited residue with nitric and hydrofluoric acids, and evaporate to dryness.
6. Add 1:3 nitric acid, boil solution and filter.
7. Discard any residue from step 6.
8. Add nitric and perchloric acids to the filtrate from step 6 and evaporate to fumes of perchloric acid.
9. Add dilute nitric acid and boil.
10. Separate the R_2O_3 group elements by an ammonium hydroxide precipitation.
11. Dissolve the precipitate in dilute nitric acid and dilute to volume.